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METHOD OF PROMOTING CERVICAL AND VAGINAL SECRETIONS

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METHOD OF PROMOTING CERVICAL AND VAGINAL SECRETIONS

This application is a continuation-in-part of U.S. Application Serial No. 09/122,516 filed July 24, 1998, which claims priority to U.S. Provisional Application Serial No. 60/054,147, filed July 25, 1997. Both applications are incorporated herein by reference.

TECHNICAL FIELD

This invention relates to a method of regulating secretions in and around the cervix and vagina of a patient by administering purinergic receptor agonists such as certain uridine, adenine, or cytidine triphosphates as well as other nucleoside phosphate containing compounds.

BACKGROUND OF THE INVENTION

Vaginal dryness is a very common problem which brings physical and emotional distress to many women (Key, E., *Nurs. Stand.* 5:24-27 (1991)). It most commonly manifests itself during sexual intercourse, which causes dyspareunia and can eventually lead to apareunia. Although it is traditionally considered to be a condition which affects postmenopausal women, it can occur during the premenopausal and perimenopausal years. The use of oral contraceptives may also cause a reduction in vaginal moisture in some women (Reginald, W., *et al.*, *Br. J. Obstet. Gynaecol.* 96:1148-1152 (1989)). Postpartum vaginal dryness, independent of or as a result of lactation, can be a significant complaint (Wisniewski, P., *et al.*, *Am. J. Obstet. Gynecol.* 165:1249-1254 (1991)). Women undergoing chemotherapy or radiotherapy for malignant diseases such as leukemia often experience vaginal dryness as a result of treatment (Cust, M., *et al.*, *Br. Med. J.* 299:1494-1497 (1989)). Many disease states, such as systemic sclerosis and other systemic autoimmune disorders (Bhaduria, S., *et al.*, *Am. J. Obstet. Gynecol.* 172:580-587 (1995)), Ehlers-Danlos syndrome (Sorokin, Y., *et al.*, *J. Reprod. Med.* 39:281-284 (1994)), diabetes

mellitus (Sreebny, L., *et al.*, *Diabetes Care* 15:900-904 (1992)), and Sjögren's syndrome (Marchesoni, D., *et al.*, *Eur. J. Obstet. Gynecol. Reprod. Biol.* 63:49-53 (1995)) have decreased vaginal hydration and lubrication problems as significant disease-associated symptoms.

5 Vulvar pain is defined as the excessive sensitivity of the nerves supplying the mucus membrane of the vulva. This persistent burning and sensitivity in vulvar skin is not caused by identifiable infection. It cannot be cured by surgery. The diseases covered under "vulvar pain" are also referred to as vulvodynia/vulvar vestibulitis, vulvitis, burning vulvar syndrome and is often associated with
10 fibromyalgia, irritable bowel syndrome, Sjögren's syndrome, chronic inflammation, and Paget's disease as well as in the absence of any identifiable disease or infection.
R. Paul St. Armad, M.D., an endocrinologist at UCLA, has successfully treated fibromyalgia with uricosuric (gout) drugs, especially guaifenesin, a drug used to liquefy mucus (Yount, J.J. *et al.*, *Women's Health Digest* 3(2) 1997). Dr. Armad has
15 found that such gout drugs provide an effective treatment for fibromyalgia, even though gout and fibromyalgia have no connection. Dr. Armad has found that 24-hour urine samples taken from patients before and after treatment exhibited a significant increase in the excretion of phosphate and a moderate increase of oxalate and calcium after guaifenesin was started. His hypothesis is that an excess of intracellular phosphate, and possibly oxalate, builds up in the cells of fibromyalgia sufferers and depresses formation of energy (ATP) in the mitochondria of the cells. It should be noted that the role of ATP in Dr. Armad's theory is as an energy source and not an agonist of the P2Y₂ receptor.
20

Current therapies for increasing vaginal moisture are: lubricating agents such as lubricating creams or jellies, topical estrogen creams, and HRT (hormone replacement therapy). Lubricating jellies provide short-lived and temporary relief, as these are aqueous preparations containing no pharmacologically active agent. Topical estrogen creams, if used on a regular basis, may be absorbed into the systemic circulation. This can cause endometrial stimulation and can lead to endometrial
25

hyperplasia and carcinoma (Whitehead, M., *et al.*, *N. Eng. J. Med.* 305:1599-1605 (1981)). HRT is effective at relieving symptoms of vaginal atrophy and hence vaginal dryness but has several contraindications and unwanted risks and side effects. A history of gall bladder disease (*N. Eng. J. Med.*, 290:15-19 (1974)) or a personal or 5 family history of reproductive or breast cancer (Harlap, S., *Am. J. Obstet. Gynecol.* 166:1986-1992 (1992)) are contraindications for estrogen therapy. Other contraindications are: history of stroke, cardiovascular disease, deep-vein thrombosis, superficial thrombophlebitis, liver disease, heavy smoking, high blood pressure, diabetes, uterine bleeding or large fibroids, hyperlipidemia, and gross obesity. 10 (Lichtman, R., *J. Nurse Midwifery* 36:30-48 (1991)). One major disadvantage of HRT is the resumption of monthly withdrawal bleeds, which many postmenopausal women will not accept. Some women, even while on HRT, still experience a degree of vaginal dryness (Key, E., *Nurs. Stand.* 5:24-27 (1991)).

It has been shown that uridine 5'-triphosphate (UTP) and dinucleotides 15 such as diuridine tetraphosphate are potent agonists of P2Y₂ purinergic receptors found on the surface of human airway epithelium. UTP has been shown to increase both the rate and total amount of mucin secreted by goblet cells *in vitro* (Lethem, M., *et al.*, *Am. J. Respir. Cell Mol. Biol.* 9:315-322 (1993)). UTP has also been shown to increase chloride secretion, and hence, water secretion from airway epithelial cells *in* 20 *vitro* (Mason, S., *et al.*, *Br. J. Pharmacol.* 103:1649-1656 (1991)).

Thus, as a result of the ineffectiveness and risks of current therapies, medical researchers have sought to develop alternatives for the treatment of vaginal dryness. Because of the demonstrated ability of UTP and dinucleotides, such as diuridine tetraphosphate, to increase hydration of airway epithelial secretions and 25 stimulate release of mucins, applicants were motivated to investigate whether UTP and other P2Y₂ and/or P2Y₄ purinergic receptor agonists could stimulate hydration and mucin production in the vaginal and cervical epithelia.

Summary of the Invention

A method of stimulating cervical and vaginal secretions in a subject in need of such treatment is disclosed. The method of the present invention may be used to increase cervical and vaginal secretions for any reason, including, but not limited to, treatment of vaginal dryness and/or treatment of vulvar pain. Vaginal dryness is 5 associated with but not limited to menopause, childbirth, breastfeeding, chemotherapy or radiotherapy, diabetes mellitus, Sjögren's syndrome, Ehlers-Danlos syndrome, systemic sclerosis and other systemic autoimmune diseases, hysterectomy, urogenital surgery, psychosomatic disorders, anxiety, psychosexual problems, and pharmacological drug-related side effects. The method of the present invention - 10 comprises administering a P_{2Y}₂ and/or P_{2Y}₄ purinergic receptor agonist: uridine 5'-triphosphate, P¹,P⁴-di(uridine-5')tetraphosphate, cytidine 5'-triphosphate or adenosine 5'-triphosphate or analogs thereof, in an amount effective to stimulate vaginal and cervical secretions.

Another aspect of the present invention is the use of uridine 5'-triphosphate, P¹,P⁴-di(uridine-5')tetraphosphate, cytidine 5'-triphosphate or adenosine 5'-triphosphate or analogs thereof, for the manufacture of a medicament for carrying out a therapeutic method of treatment as given above.

The present invention also discloses pharmaceutical compositions comprising uridine 5'-triphosphate, P¹,P⁴-di(uridine-5')tetraphosphate, cytidine 5'-triphosphate or adenosine 5'-triphosphate or analogs thereof, with a pharmaceutical carrier therefor.

DETAILED DESCRIPTION OF THE INVENTION

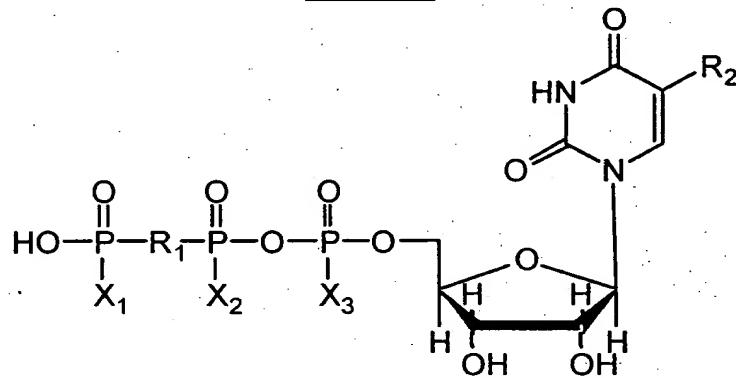
Applicants have discovered that uridine 5'-triphosphate (UTP) and related 25 compounds are potent agonists for purinergic receptors found in cervical and vaginal epithelia preparations. The methods of the present invention are an improvement upon the current most commonly used treatments of vaginal dryness as UTP stimulates a patient's own production and secretion of mucins as well as increasing the levels of mucosal hydration, which serve to maintain the natural protective and

lubricant characteristics of vaginal and cervical mucosa. The methods of the present invention may also be used exclusive of, or as an adjunct to, hormone replacement therapy (HRT) or estrogen replacement therapy (ERT).

- The present invention provides a method of stimulating cervical and vaginal secretions in a mammal, including a human, in need thereof by administering an amount of a compound of Formulas I, II, III, or IV or a pharmaceutically acceptable ester or salt thereof effective to increase said secretions.

UTP and its analogs are depicted in general Formula I:

Formula I



10

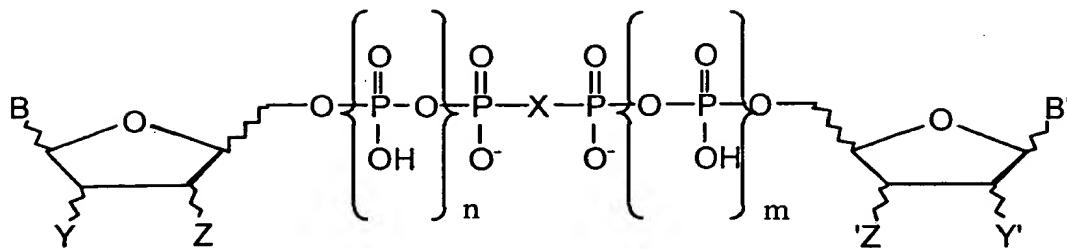
wherein:

- X₁, X₂ and X₃ are each independently either O⁻ or S⁻; preferably, X₂ and X₃ are O⁻;
- 15 R₁ is O, imido, methylene or dihalomethylene (e.g., dichloromethylene or difluoromethylene); preferably, R₁ is oxygen or difluoromethylene;
- R₂ is H or Br; preferably, R₂ is H; particularly preferred compounds of Formula I are uridine 5'-triphosphate (UTP) and uridine 5'-O-(3-thiotriphosphate) (UTP_γS).

A dinucleotide is depicted by the general Formula II:

20

Formula II



wherein:

X is oxygen, methylene, difluoromethylene, imido;

5 n = 0, 1, or 2;

m = 0, 1, or 2;

n + m = 0, 1, 2, 3, or 4; and

10 B and B' are each independently a purine residue or a pyrimidine residue linked through the 9- or 1-position, respectively;

Z = OH or N₃;

Z' = OH or N₃;

Y = H or OH;

Y' = H or OH;

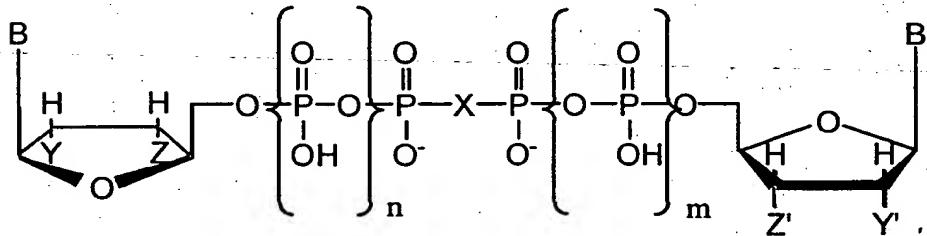
provided that when Z is N₃, Y is H or when Z' is N₃, Y' is H.

15 The furanose sugar is preferably in the β -configuration.

The furanose sugar is most preferably in the β -D-configuration.

Preferred compounds of Formula II are the compounds of Formula IIa:

Formula IIa



20 wherein:

X = O;

n + m = 1 or 2;

Z, Z', Y, and Y'=OH;

B and B' are defined in Formulas IIc and IIId; 6 ✓

5 X=O;

n+m=3 or 4;

Z, Z', Y, and Y'=OH;

B=uracil;

B' is defined in Formulas IIc and IIId; or

10 X=O;

n+m=1 or 2;

Z, Y, and ~~Z'~~=OH;

Y ~~Z'~~=H;

B=uracil;

15 B' is defined in Formulas IIc and IIId; or

X=O;

n+m=0, 1, or 2;

Z and Y=OH;

Z'=N₃;

20 Y'=H;

B=uracil;

B'=thymine; or

X=O;

n+m=0, 1, or 2;

25 Z and Z'=N₃;

Y and Y'=H;

B and B'=thymine; or

X=CH₂, CF₂, or NH;

n and m=1;

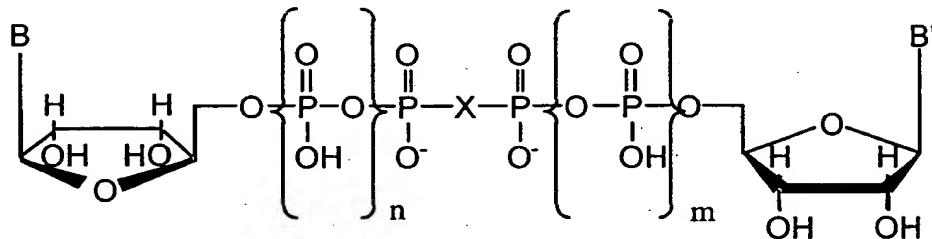
Z, Z', Y, and Y'=OH;

B and B' are defined in Formulas IIc and IId.

Another preferred group of the compounds of Formula II are the compounds of Formula IIb or the pharmaceutically acceptable salts thereof:

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Formula IIb

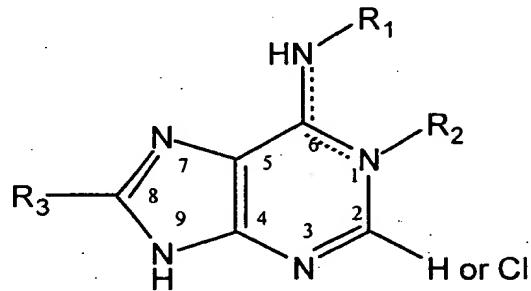


wherein:

- 10 X is oxygen, methylene, difluoromethylene, or imido;
- n = 0 or 1;
- m = 0 or 1;
- n + m = 0, 1, or 2; and
- 15 B and B' are each independently a purine residue, as in Formula IIc, or a pyrimidine residue, as in Formula IId, linked through the 9- or 1-position, respectively. In the instance where B and B' are uracil, attached at N-1 position to the ribosyl moiety, then the total of m + n may equal 3 or 4 when X is oxygen. The ribosyl moieties are in the D- configuration, as shown, but may be L-, or D- and L-. The D- configuration is preferred.

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Formula IIc



The substituted derivatives of adenine include adenine 1-oxide; 1,N6-(4-

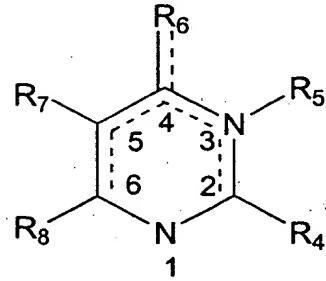
or 5-substituted etheno) adenine; 6-substituted adenine; or 8-substituted
aminoadenine, where R' of the 6- or 8-HNR' groups are chosen from among:

- 5 arylalkyl (C_{1-6}) groups with the aryl moiety optionally functionalized as described
below; alkyl; and alkyl groups with functional groups therein, such as:
([6-aminohexyl]carbamoylmethyl)-, and ω -acylated-amino(hydroxy, thiol and
carboxy) derivatives where the acyl group is chosen from among, but not limited to,
acetyl, trifluororoacetyl, benzoyl, substituted-benzoyl, etc., or the carboxylic moiety is
10 present as its ester or amide derivative, for example, the ethyl or methyl ester or its
methyl, ethyl or benzamido derivative. The ω -amino(hydroxy, thiol) moiety may be
alkylated with a C_{1-4} alkyl group.

Likewise, B' or B' or both in Formula IIb may be a pyrimidine with the
general formula of Formula IIId, linked through the 1-position:

15

Formula IIId



wherein:

- R₄ is hydroxy, mercapto, amino, cyano, aralkoxy, C_{1-6} alkoxy, C_{1-6}
alkylamino, and dialkylamino, the alkyl groups optionally linked to form a
20 heterocycle;

R₅ is hydrogen, acyl, C_{1-6} alkyl, aroyl, C_{1-5} alkanoyl, benzoyl, or
sulphonate;

R₆ is hydroxy, mercapto, alkoxy, aralkoxy, C₁₋₆-alkylthio, C₁₋₅ disubstituted amino, triazolyl, alkylamino, or dialkylamino, where the alkyl groups are optionally linked to form a heterocycle or linked to N-3 to form an optionally substituted ring;

5 R₇ is hydrogen, hydroxy, cyano, nitro, alkenyl, with the alkenyl moiety optionally linked through oxygen to form a ring optionally substituted on the carbon adjacent to the oxygen with alkyl or aryl groups, substituted alkynyl or hydrogen where R₈ is amino or substituted amino and halogen, alkyl, substituted alkyl, perhalomethyl (e.g., CF₃), C₂₋₆ alkyl, C₂₋₃ alkenyl, or substituted ethenyl (e.g., 10 allylamino, bromvinyl and ethyl propenoate, or propenoic acid), C₂₋₃ alkynyl or substituted alkynyl when R₆ is other than amino or substituted amino and together R₅ - R₆ may form a 5- or 6-membered saturated or unsaturated ring bonded through N or O at R₆, such a ring may contain substituents that themselves contain functionalities;

15 R₈ is hydrogen, alkoxy, arylalkoxy, alkylthio, arylalkylthio, carboxamidomethyl, carboxymethyl, methoxy, methylthio, phenoxy, or phenylthio.

In the general structure of Formula IIc above, the dotted lines in the 2- to 6-positions are intended to indicate the presence of single or double bonds in these positions; the relative positions of the double or single bonds being determined by whether the R₄, R₆, and R₇ substituents are capable of keto-enol tautomerism.

20 In the general structures of Formula IIc and IIId above, the acyl groups advantageously comprise alkanoyl or aroyl groups. The alkyl groups advantageously contain 1 to 8 carbon atoms, particularly 1 to 4 carbon atoms optionally substituted by one or more appropriate substituents, as described below. The aryl groups including the aryl moieties of such groups as aryloxy are preferably phenyl groups optionally 25 substituted by one or more appropriate substituents, as described below. The above mentioned alkenyl and alkynyl groups advantageously contain 2 to 8 carbon atoms, particularly 2 to 6 carbon atoms, e.g., ethenyl or ethynyl, optionally substituted by one or more appropriate substituents as described below. Appropriate substituents on the above-mentioned alkyl, alkenyl, alkynyl, and aryl groups are advantageously selected

from halogen, hydroxy, C₁₋₄ alkoxy, C₁₋₄ alkyl, C₆₋₁₂ arylalkoxy, carboxy, cyano, nitro, sulfonamido, sulfonate, phosphate, sulfonic, amino, and substituted amino wherein the amino is singly or doubly substituted by a C₁₋₄ alkyl, and when doubly substituted, the alkyl groups optionally being linked to form a heterocycle.

5 For purposes of further clarifying the foregoing descriptions of Formulae IIc and IId, the descriptions can be simplified to the following:

R₂ is O or is absent; or

R₁ and R₂ taken together may form optionally substituted 5-membered fused imidazole ring; or

10 R₁ of the 6-HNR₁ group or R₃ of the 8-HNR₃ group is chosen from the group consisting of:

(a) arylalkyl (C₁₋₆) groups with the aryl moiety optionally substituted,

(b) alkyl,

15 (c) ([6-aminohexyl]carbamoylmethyl),

(d) ω-amino alkyl (C₂₋₁₀),

(e) ω-hydroxy alkyl (C₂₋₁₀),

(f) ω-thiol alkyl (C₂₋₁₀),

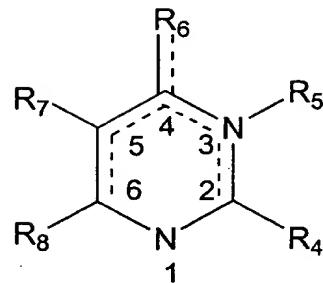
(g) ω-carboxy alkyl (C₂₋₁₀),

20 (h) the ω-acylated derivatives of (b), (c) or (d) wherein the acyl group is either acetyl, trifluoroacetyl, benzoyl, or substituted-benzoyl alkyl(C₂₋₁₀), and

(i) ω-carboxy alkyl (C₂₋₁₀) as in (e) above wherein the carboxylic moiety is an ester or an amide;

25

Formula IIId



wherein:

R₄ is hydroxy, mercapto, amino, cyano, aralkoxy, C₁₋₆ alkylthio, C₁₋₆ alkoxy, C₁₋₆ alkylamino or dialkylamino, wherein the alkyl groups of said dialkylamino are optionally linked to form a heterocycle;

R₅ is hydrogen, acyl, C₁₋₆ alkyl, aroyl, C₁₋₅ alkanoyl, benzoyl, or sulphonate;

R₆ is hydroxy, mercapto, alkoxy, aralkoxy, C₁₋₆-alkylthio, C₁₋₅ disubstituted amino, triazolyl, alkylamino or dialkylamino, wherein the alkyl groups of said dialkylamino are optionally linked to form a heterocycle or linked to N³ to form an optionally substituted ring;

R₅ - R₆ together forms a 5 or 6-membered saturated or unsaturated ring bonded through N or O at R₆, wherein said ring is optionally substituted;

R₇ is selected from the group consisting of:

- (a) hydrogen,
- (b) hydroxy,
- (c) cyano,
- (d) nitro,
- (e) alkenyl, wherein the alkenyl moiety is optionally linked through oxygen to form a ring optionally substituted with alkyl or aryl groups on the carbon adjacent to the oxygen,
- (f) substituted alkynyl
- (g) halogen,

- (h) alkyl,
- (i) substituted alkyl,
- (j) perhalomethyl,
- (k) C₂₋₆ alkyl,
- 5 (l) C₂₋₃ alkenyl,
- (m) substituted ethenyl,
- (n) C₂₋₃ alkynyl and
- (o) substituted alkynyl when R₆ is other than amino or substituted amino;

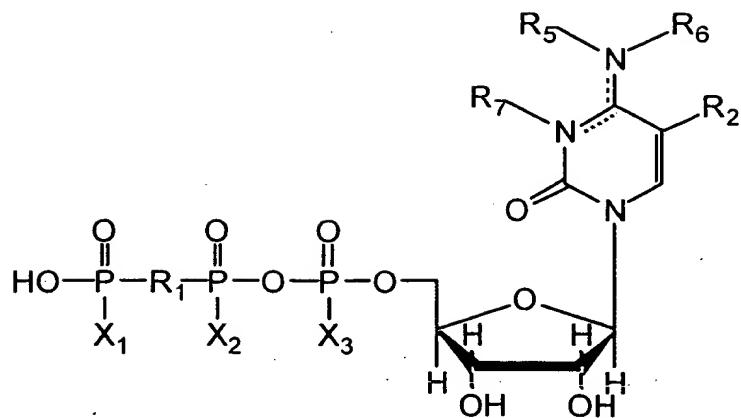
10 R₈ is selected from the group consisting of:

- (a) hydrogen,
- (b) alkoxy,
- (c) arylalkoxy,
- (d) alkylthio,
- 15 (e) arylalkylthio,
- (f) carboxamidomethyl,
- (g) carboxymethyl,
- (h) methoxy,
- (i) methylthio,
- 20 (j) phenoxy and
- (k) phenylthio.

CTP and its analogs are depicted by general Formula III:

25

Formula III



wherein:

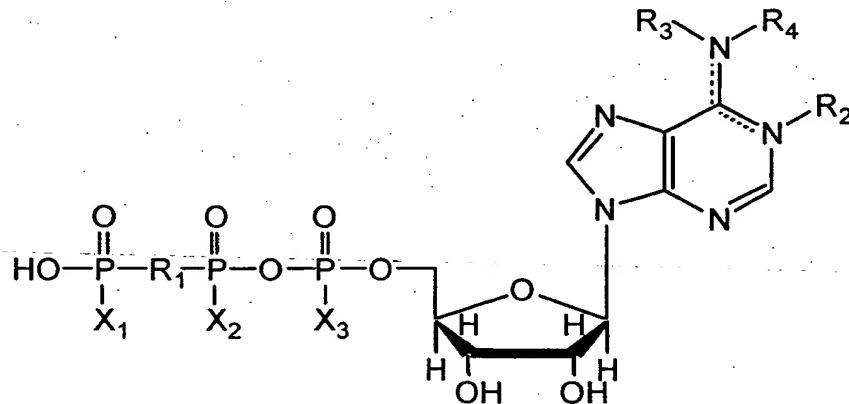
R₁, X₁, X₂ and X₃ are defined as in Formula I;

5 R₅ and R₆ are H while R₇ is nothing and there is a double bond between N-3 and C-4 (cytosine), or

R₅, R₆ and R₇ taken together are -CH=CH-, forming a ring from N-3 to N-4 with a double bond between N-4 and C-4 (3,N⁴-ethenocytosine) optionally substituted at the 4- or 5-position of the etheno ring.

10 ATP and its analogs are depicted by general Formula IV:

Formula IV



15 wherein:

R₁, X₁, X₂, and X₃ are defined as in Formula I;

R₃ and R₄ are H while R₂ is nothing and there is a double bond between N-1 and C-6 (adenine), or

R₃ and R₄ are H while R₂ is O and there is a double bond between N-1 and C-6 (adenine 1-oxide), or

5 R₃, R₄, and R₂ taken together are -CH=CH-, forming a ring from N-6 to N-1 with a double bond between N-6 and C-6 (1,N6-ethenoadenine).

For simplicity, Formulas I, II, III, and IV herein illustrate the active compounds in the naturally occurring D-configuration, but the present invention also encompasses compounds in the L-configuration, and mixtures of compounds in the D-10 and L-configurations, unless otherwise specified. The naturally occurring D-configuration is preferred.

The compounds of the invention may be present in the form of their pharmaceutically acceptable salts, such as, but not limited to, an alkali metal salt such as sodium or potassium; an alkaline earth metal salt such as manganese, magnesium, 15 or calcium; or an ammonium or tetraalkyl ammonium salt, i.e., NX₄⁺ (wherein X is C₁₋₄). Pharmaceutically acceptable salts are salts that retain the desired biological activity of the parent compound and do not impart undesired toxicological effects. The compounds of the invention may also be present in the form of prodrugs, typically comprising esters or amide moieties on the heterocyclic and furanosyl 20 hydroxyls of the compound.

Another aspect of the present invention is a method of treating a mammal with vaginal dryness arising from, but not limited to, menopause, childbirth, breastfeeding, chemotherapy or radiotherapy, diabetes mellitus, Sjögren's syndrome, Ehlers-Danlos syndrome, systemic sclerosis and other systemic autoimmune diseases, 25 hysterectomy, urogenital surgery, psychosomatic disorders, anxiety, psychosexual problems, and pharmacological drug-related side effects.

It is also contemplated that the method of the present invention can be used to increase vaginal moisture and lubrication in healthy women for the purpose of facilitating sexual intercourse. It is further contemplated that the method of the

present invention would be particularly useful for a woman who wished to accommodate a sexual partner who is undergoing treatment with Viagra® or other such drugs used for the treatment of erectile dysfunction.

- The present invention further provides pharmaceutical compositions comprising a dosage form containing either P2Y₂ and/or P2Y₄ purinergic receptor agonists selected from the group consisting of general Formula I, i.e., uridine 5'-triphosphate [UTP] and its analogs, general Formula II, i.e., P¹,P⁴-di(uridine-5') tetraphosphate [U₂P₄] and its analogs, general Formula III, i.e., cytidine 5'-triphosphate [CTP] and its analogs, and general Formula IV, i.e., adenosine 5'-triphosphate [ATP] and its analogs.

The compounds disclosed herein may be administered to the cervical and/or vaginal mucosa of a patient by any suitable means, but are preferably administered by a solution, gel, suspension, cream, foam, pessary, or tablet containing the active compound. Alternatively, the active compounds may be administered by continuous release from a vaginal ring (Stumpf, P., *Obstet. Gynecol.* 75:9S (1990)) or 15 an intrauterine device (Andersson, K., et al., *Obstet. Gynecol.* 79:963 (1992)).

The topical solution, gel, jelly, ointment, cream, foam, pessary, or tablet contain the active compound in a physiologically compatible vehicle, as those skilled in the art of gynecological topical delivery system development can select using 20 conventional criteria.

Solutions formulated for administration to the vagina are usually referred to as irrigations. These are sterile solutions, prepared in a manner typical of sterile injections that are intended for prepared as a single use sterile solution.

Gels or jellies may be produced using a suitable gelling agent including, 25 but not limited to, gelatin, tragacanth, or a cellulose derivative and may include glycerol as a humectant, emollient, and preservative.

Ointments are semi-solid preparations that consist of the active ingredient incorporated into a fatty, waxy, or synthetic base.

Examples of suitable creams include, but are not limited to, water-in-oil and oil-in-water emulsions. Water-in-oil creams may be formulated by using a suitable emulsifying agent with properties similar, but not limited, to those of the fatty alcohols such as cetyl alcohol or cetostearyl alcohol and to emulsifying wax. Oil-in-
5 water creams may be formulated using an emulsifying agent such as cetomacrogol emulsifying wax. Suitable properties include the ability to modify the viscosity of the emulsion and both physical and chemical stability over a wide range of pH. The water soluble or miscible cream base may contain a preservative system and may also be buffered to maintain an acceptable physiological pH.

10 Foam preparations may be formulated to be delivered from a pressurized aerosol canister, via a suitable applicator, using inert propellants. Suitable excipients for the formulation of the foam base include, but are not limited to, propylene glycol, emulsifying wax, cetyl alcohol, and glyceryl stearate. Potential preservatives include methylparaben and propylparaben.

15 Pessaries are solid unit-dose forms suitably shaped for insertion into the vagina and may either be composed of a base that melts at body temperature or which dissolves when in contact with mucous secretions. Examples of suitable bases include, but are not limited to, theobroma oil, synthetic fat bases (e.g. Witepsol), polyethylene glycols (macrogols), and glycerol suppository basis.

20 Vaginal tablets are composed of the active ingredient contained within a solid dosage form base which may include, but not be limited to, excipients such as lactose, microcrystalline cellulose, corn starch, magnesium stearate, silicon dioxide, and hydroxypropyl methylcellulose.

25 In addition to the topical method of administration described above, there are various methods of administering the compounds of the present invention systemically. One such means would involve an aerosol suspension of respirable particles comprised of the active compound, which the subject inhales. The active compound would be absorbed into the bloodstream via the lungs and contact the cervical and/or vaginal tissues in a pharmaceutically effective amount. The respirable

particles may be liquid or solid, with a particle size sufficiently small to pass through the mouth and larynx upon inhalation; in general, particles ranging from about 1 to 10 microns, but more preferably 1-5 microns, in size are considered respirable.

Another means of systemically administering the active compounds to the cervical and vaginal tissues of the subject would involve administering a liquid/liquid suspension in the form of nasal drops of a liquid formulation, or a nasal spray of respirable particles which the subject inhales. Liquid pharmaceutical compositions of the active compound for producing a nasal spray or nasal drops may be prepared by combining the active compound with a suitable vehicle, such as sterile pyrogen free water or sterile saline by techniques known to those skilled in the art.

Other means of systemic administration of the active compound would involve oral administration, in which pharmaceutical compositions containing compounds of Formulas I, II, III, or IV are in the form of tablets, lozenges, aqueous or oily suspensions, dispersible powders or granules, emulsion, hard or soft capsules, or syrups or elixirs. Compositions intended for oral use may be prepared according to any method known to the art for the manufacture of pharmaceutical compositions and such compositions may contain one or more agents selected from the group consisting of sweetening agents, flavoring agents, coloring agents, and preserving agents in order to provide pharmaceutically elegant and palatable preparations. Tablets contain the active ingredient in admixture with nontoxic pharmaceutically acceptable excipients which are suitable for the manufacture of tablets. These excipients may be, for example, inert diluents, such as calcium carbonate, sodium carbonate, lactose, calcium phosphate, or sodium phosphate; granulating and disintegrating agents, for example, corn starch or alginic acid; binding agents, for example, starch, gelatin, or acacia; and lubricating agents, for example magnesium stearate, stearic acid, or talc. The tablets may be uncoated or they may be coated by known techniques to delay disintegration and absorption in the gastrointestinal tract and thereby provide a sustained action over a longer period. For example, a time delay material such as glyceryl monostearate or glyceryl distearate may be employed. Formulations for oral

use may also be presented as hard gelatin capsules wherein the active ingredient is mixed with an inert solid diluent, for example, calcium carbonate, calcium phosphate, or kaolin, or as soft gelatin capsules wherein the active ingredient is mixed with water or an oil medium, for example, peanut oil, liquid paraffin, or olive oil.

5 Additional means of systemic administration of the active compound to the cervical and vaginal tissues of the subject would involve a suppository form of the active compound, such that a therapeutically effective amount of the compound reaches the cervical and vaginal tissues via systemic absorption and circulation.

The quantity of the active compound included in the pharmaceutical
10 composition is an amount sufficient to achieve concentrations of the active compound on the cervical and/or vaginal mucosa of the subject of from about 10^{-7} to about 10^{-1} Moles/liter, and more preferably from about 10^{-6} to about 10^{-1} Moles/liter.

Depending on the solubility of the particular formulation of active
15 compound administered, the daily dose to promote cervical and/or vaginal mucin production and/or hydration may be divided among one or several unit dose administrations. The total daily dose for UTP (for example) may range from 1 to 1000 milligrams, depending upon the age and state of the subject, given at a regimen of up to four times per day or on an as needed basis to address acute exacerbations.

Some compounds of Formulas I, II, III, and IV can be made by methods
20 which are well known to those skilled in the art and in accordance with known procedures (Zamecnik, P., *et al.*, *Proc. Natl Acad. Sci. USA* 89:2370-2373 (1992); Ng, K., *et al.*, *Nucleic Acids Res.* 15:3572-3580 (1977); Jacobus, K.M., *et al.*, U.S. Patent No. 5,789,391 and Pendegast, W., *et al.*, International Patent Application WO98/34942)); some are commercially available, for example, from Sigma Chemical Company, PO Box 14508, St. Louis, MO 63178. The synthetic methods of U.S. Patent 5,789,391 and International Patent Application WO98/34942 are incorporated herein by reference.

Examples**Example 1: In Vitro short circuit (I_{sc}) measurements**

The compound UTP is a potent agonist of P2Y₂ and/or P2Y₄ purinergic receptors in cervical and vaginal tissue preparations by evaluation *in vitro* by 5 administering UTP to the tissue culture sufficient to achieve concentrations of UTP on the mucosa of from about 10⁻⁷ to about 10⁻¹ moles/liter. (Rojanasakul, Y., *et al.*, *Pharm. Res.* 9:1029-34 (1992); Bechgaard, E., *et al.*, *Int. J. Pharm.* 106:237-242 (1994); Gipson, I., *et al.*, *Biol. Reprod.* 56:999-1011, (1997)). Specifically, 10 ovariectomized female white albino New Zealand rabbits are sacrificed and vaginal tissue is removed. The tissue is mounted on a supporting ring and clamped in an Ussing chamber. I_{sc} is measured as flowing from the epithelial side to the serosal side of the tissue. Approximately half of this current corresponds to chloride movement through the membrane and hence, this is an accurate measure of the corresponding fluid movement.

15 Example 2. *In vivo* study in rabbits

The compounds of the invention are evaluated *in vivo* by administrating UTP, or any of the other P2Y₂ and/or P2Y₄ agonists of the present invention to an animal in an amount sufficient to achieve concentrations of P2Y₂ and/or P2Y₄ agonist on the cervical and/or vaginal mucosa of the animal of from about 10⁻⁷ to about 10⁻¹ 20 moles/liter (Richardson, J., *et al.*, *Int. J. Pharm.* 56:29-35 (1989)). Specifically, ovariectomized female white albino New Zealand rabbits are dosed with a P2Y₂ and/or P2Y₄ agonist such as any of the compounds of the present invention. A vaginal smear is then obtained with a cotton swab. The sample is appropriately prepared, an ELISA or a colorimetric dot blot method is run on the sample, and the 25 relative amounts of representative cervical mucins are determined as compared to non-ovariectomized controls. (Gipson, I. *et al.*, *Biol. Reprod.* 56:999-1011 (1997)).

Example 3. *In vivo* study using ovariectomized cynologous monkeys

The compounds of the present invention are evaluated *in vivo* with an animal model of vaginal dryness as follows. Ovariectomized cynomolgus monkeys are

examined before treatment and graded subjectively using a vaginal atrophy index. The animals were then dosed intravaginally with 100 to 300 μ l mist containing 10^{-2} to 1 moles/liter P2Y₂ and/or P2Y₄ agonist, such as any of the compounds of the present invention. After 10, 20, 30, 60 and 90 minutes the animals are subjected to a 5 gynecological exam and graded by qualified medical professions with the vaginal atrophy index on a scale of 1 to 5, including a measurement of fluid pH. (Hubbard, G. et al., *Lab Animal Sci.* 47, 36-39, (1997)).

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